MLS O_3 comparisons versus O_3 from

HALOE, SAGE II, ACE, POAM III, MIPAS, sondes,

PAVE lidars (AROTAL, DIAL), PAVE microwave (ASUR)

L. Froidevaux (JPL)

Y. Jiang, R. Fuller, N. Livesey, W. Read, J. Waters & MLS team members

+ teams for the above measurement systems

+ B. Bojkov/AVDC

Introduction / Approach: MLS ozone comparisons

- Use main O_3 product from MLS, namely 240 GHz radiometer (several lines).

- Other bands provide information but not as good a vertical range & precision; systematic differences are observed between the bands, but generally not outside expectations, see IEEE paper (roughly 5 - 7% accuracy is expected for each MLS band in mid- to upper stratosphere).

- No major issues in radiance residuals observed so far; band 7 data for this standard product gives residuals within 0.5 K (3 %) ,1 K for some channels. rms residuals generally match the rms noise.

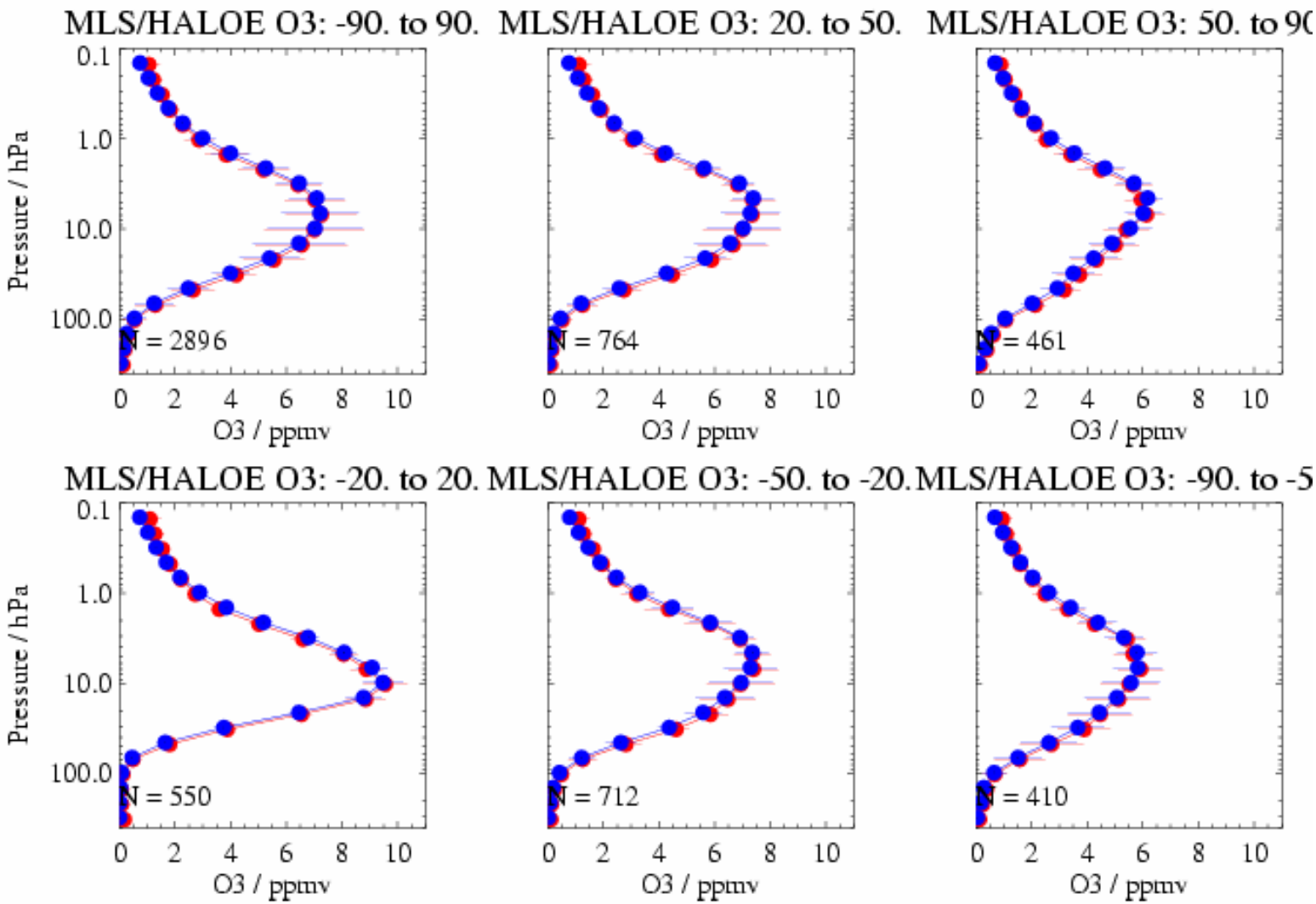
- Single profile precision in stratosphere ~ 2 to 10%; empirical precision (scatter in narrow 'quiet' lat. bin) is somewhat higher than est. precision.

- Show many O_3 comparisons, generally with enough precision to detect some biases between datasets.

- Analyze variations / differences versus latitude and time (e.g., monthly).

- Summary and future work

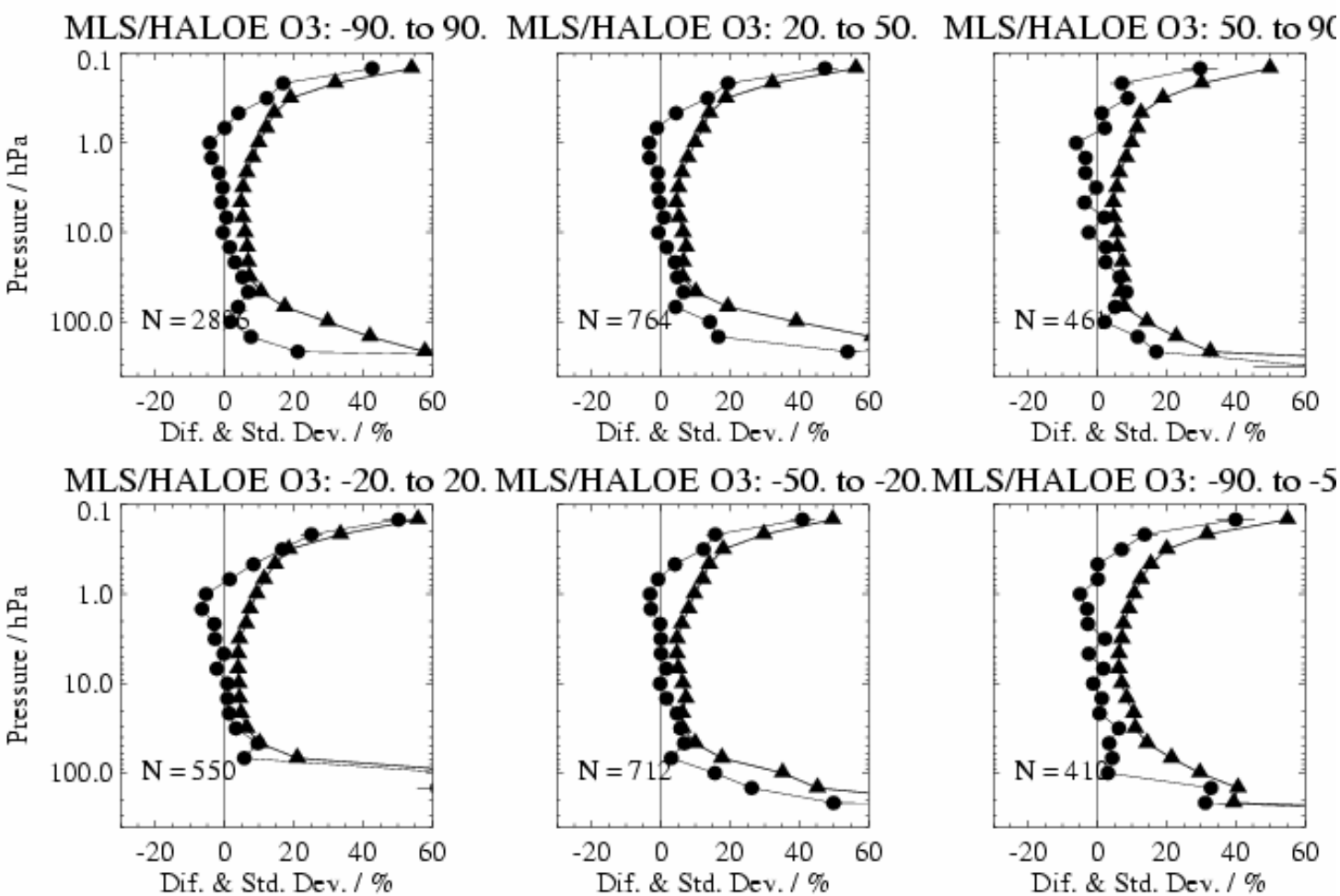
MLS O_3 vs HALOE O_3 : Aug 04-July 05



Matched (coincident) profiles within 1 deg. Lat., 8 deg. Lon., 12 hours (same day).

Excellent agreeement overall, but look in more detail at percent differences.

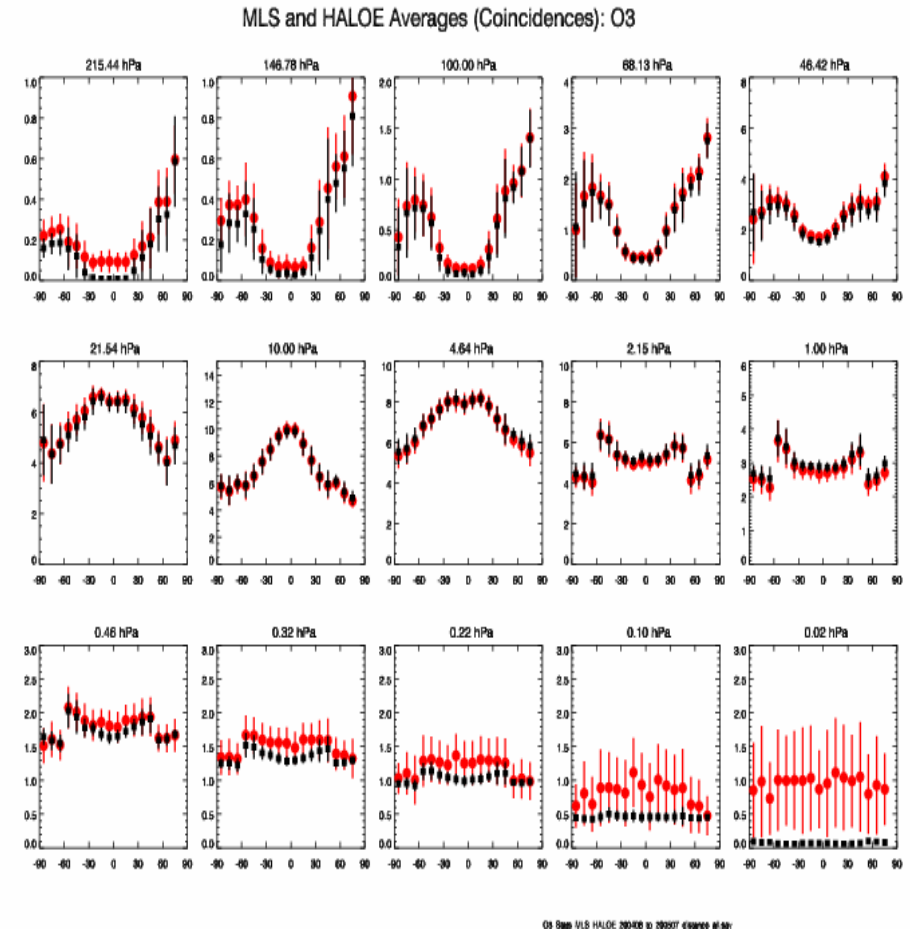
MLS O_3 vs HALOE O_3 : Aug 04-July 05 Percent Difs.

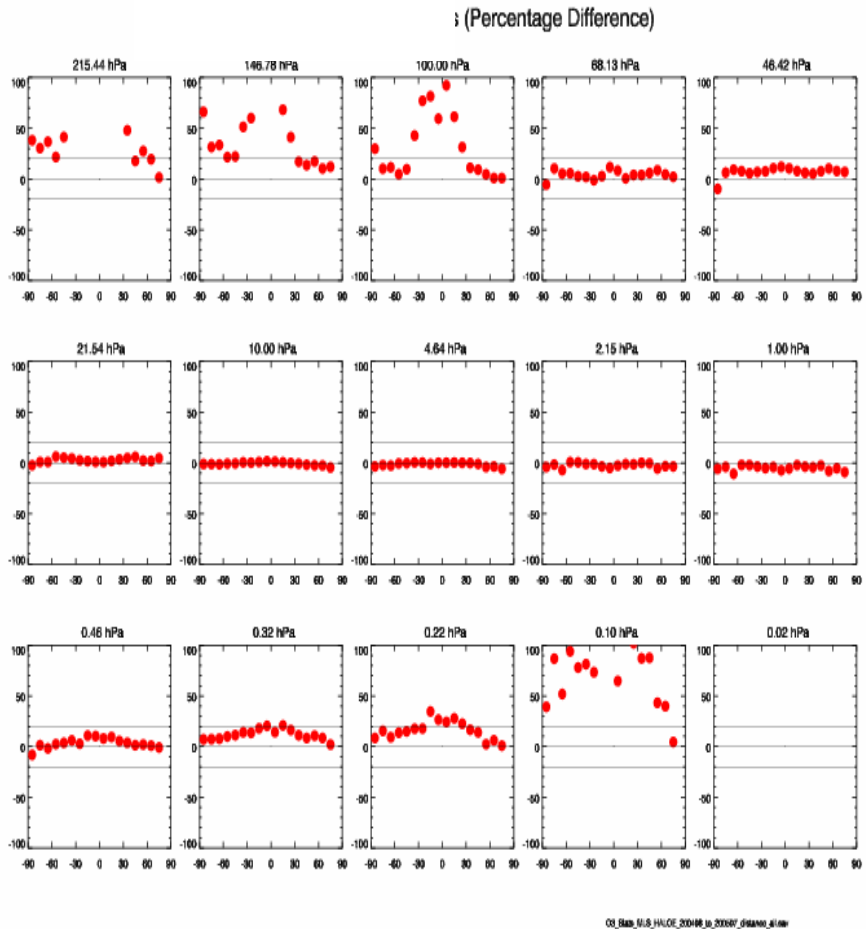


- Excellent agreement but there is a slope vs height in these % difs.
- Seen to various degrees in most of the comparisons below.
- Mes. and UT/LS exhibit worst % difs.

Matched (coincident) profiles within 1 deg. Lat., 8 deg. Lon., 12 hr (same day)
- dots are avg. difs with error bar = 2 x est. precision in difs.
- triangles are std. dev. of difs.

MLS O_3 vs HALOE O_3



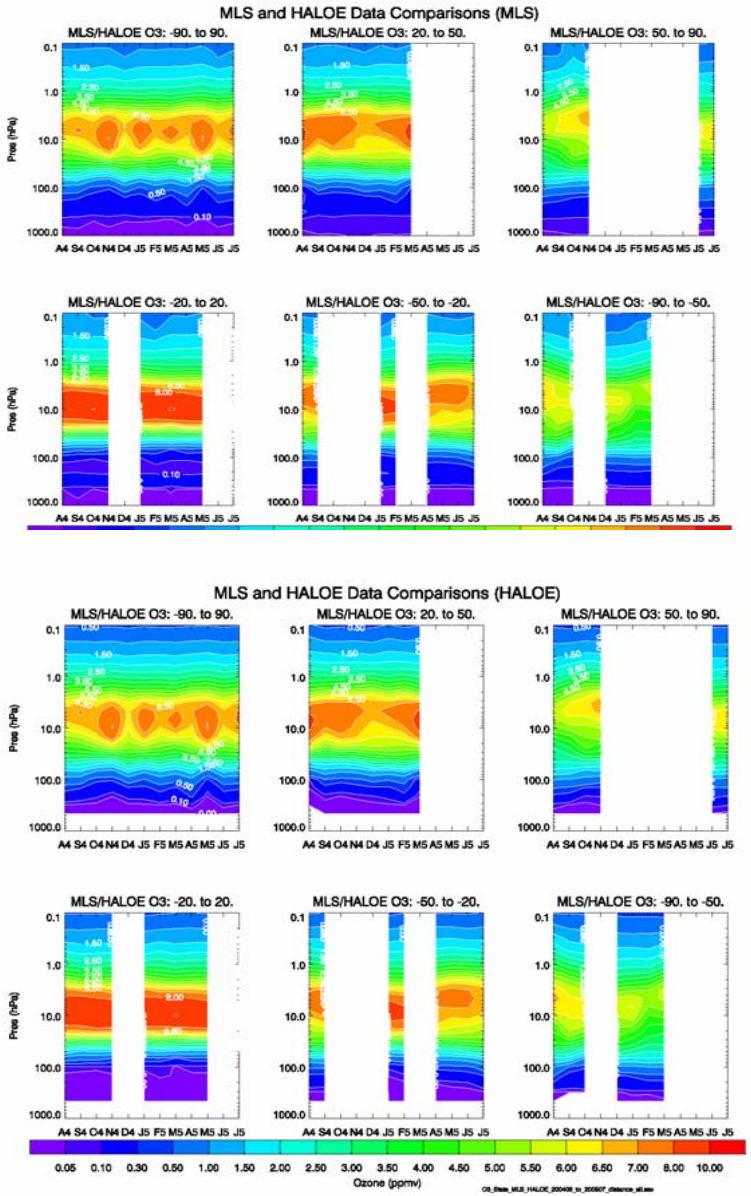


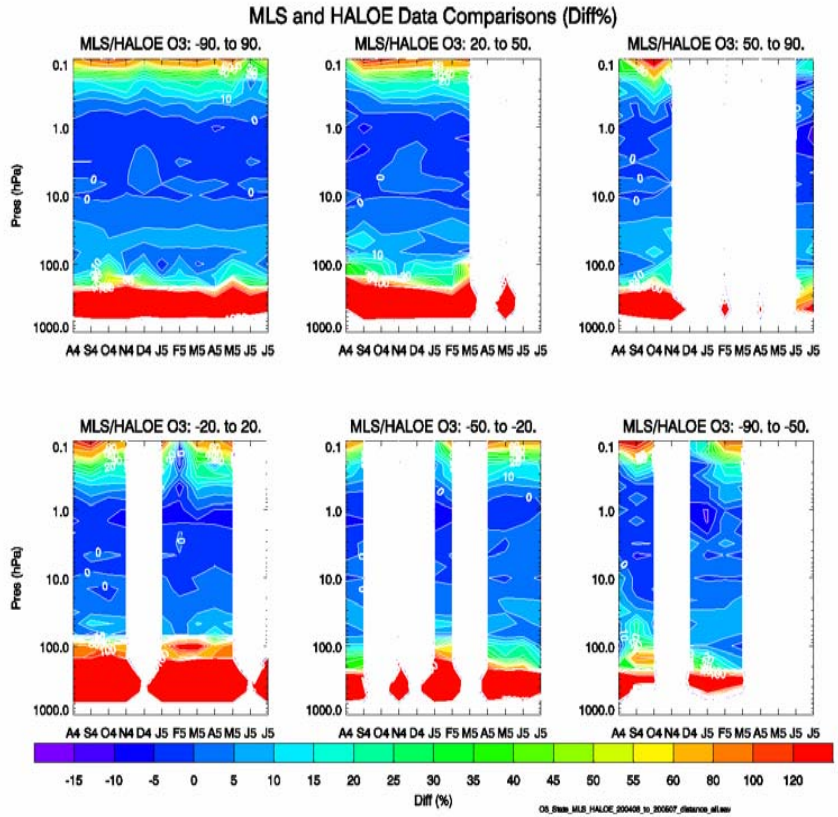
Differences (for avg. coincident profiles) versus latitude.

Stratospheric percent differences are generally constant vs latitude.

Highest % biases are at low latitudes (UT) and in mesosphere.

MLS O3 vs HALOE O3: Stability of monthly avg. diffs. versus time





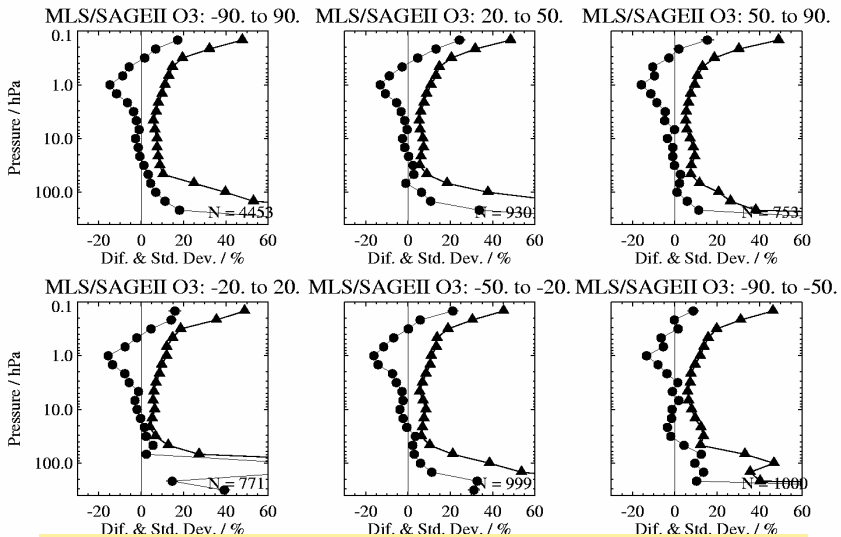
- Average differences overall appear to be stable for this past year of data.

- Scatter about the means also tracks well overall (not shown) → profile-to-profile variability in atmosphere tracks well for these coincidences, as it should.

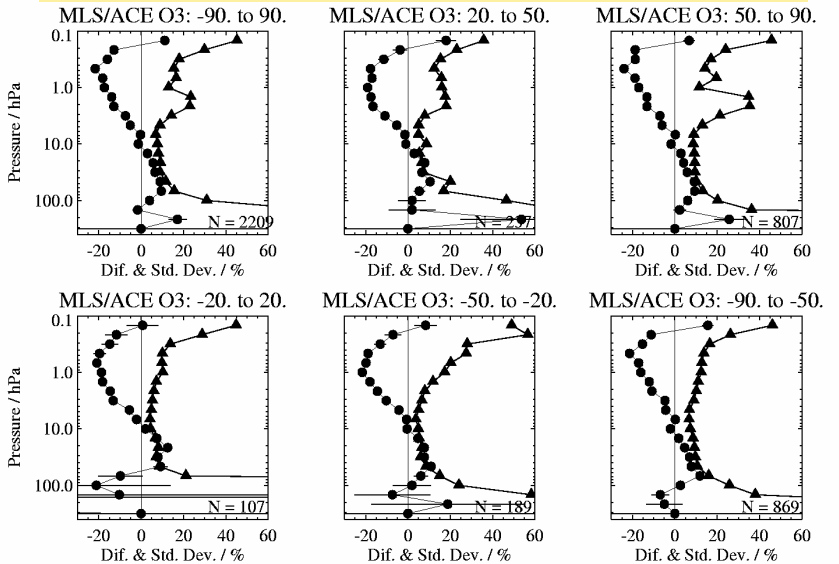
- Will look at these difs. vs time more closely

MLS O_3 % Differences versus SAGE II , ACE, POAM III

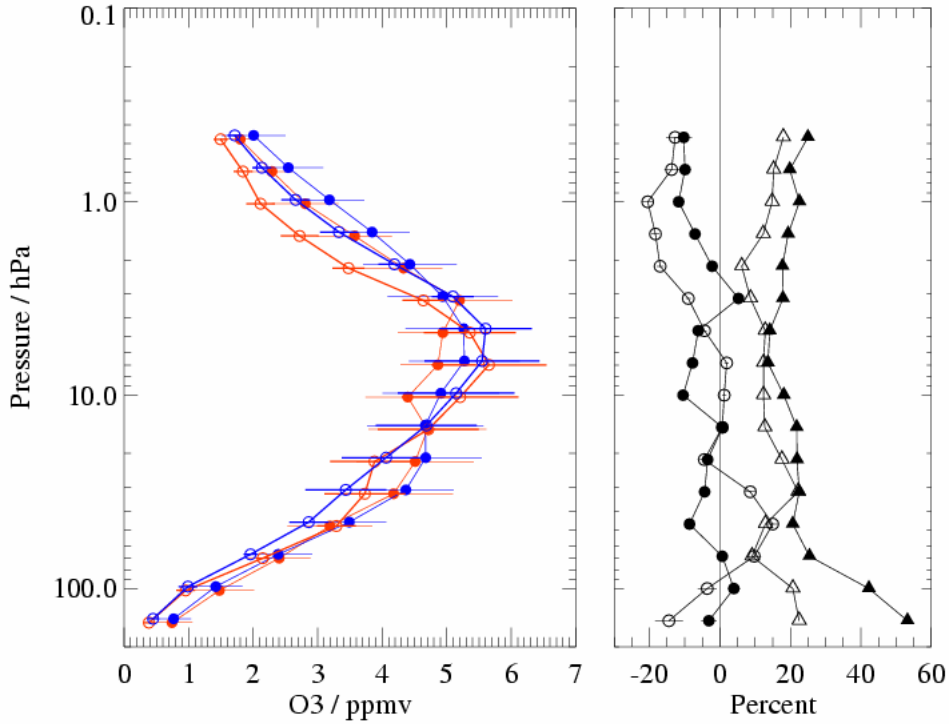
MLS vs SAGE II for ~ 1 year of data



MLS vs ACE for ~ 1 year of data



MLS/POAM III Jan-Mar 2005 results
(not updated for 1 full year yet)



- Sloping differences, to varying degrees, between MLS and other occultation datasets.

- Effect of day, night, SR, SS looked at to some extent, but no ‘silver bullet’ yet.

2005

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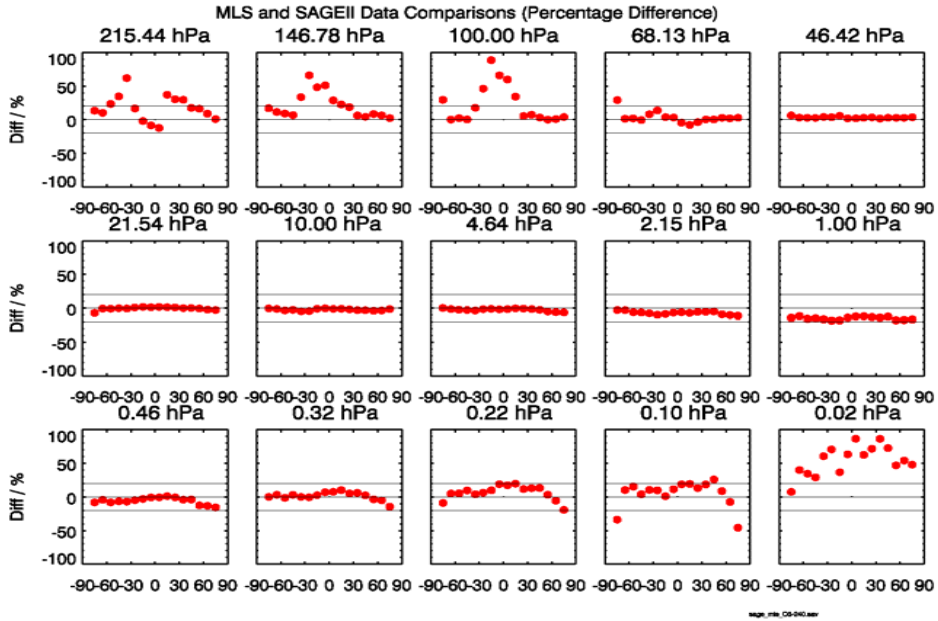
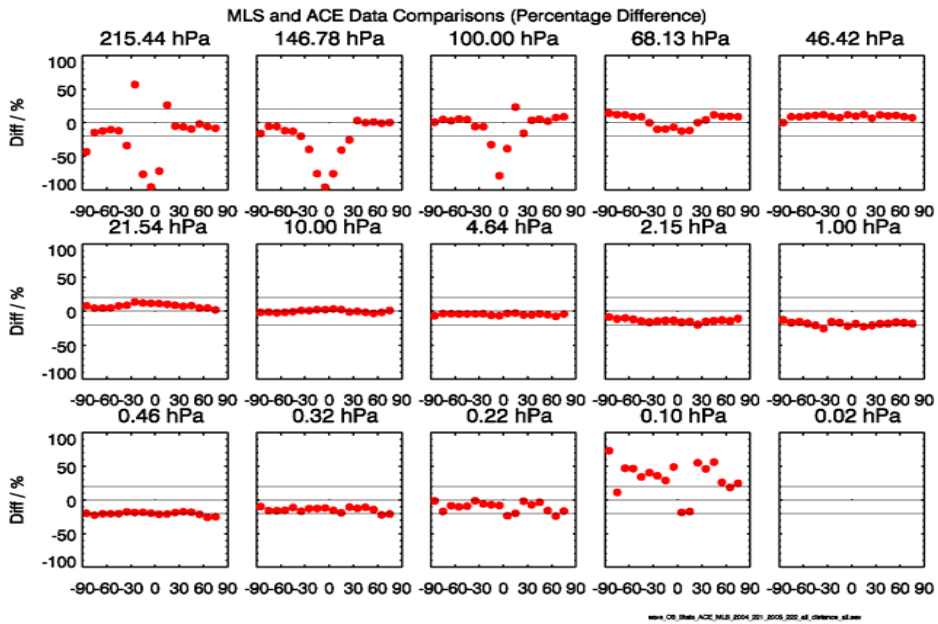


MLS vs SAGE II for ~ 1 year of data

Good stability vs latitude.

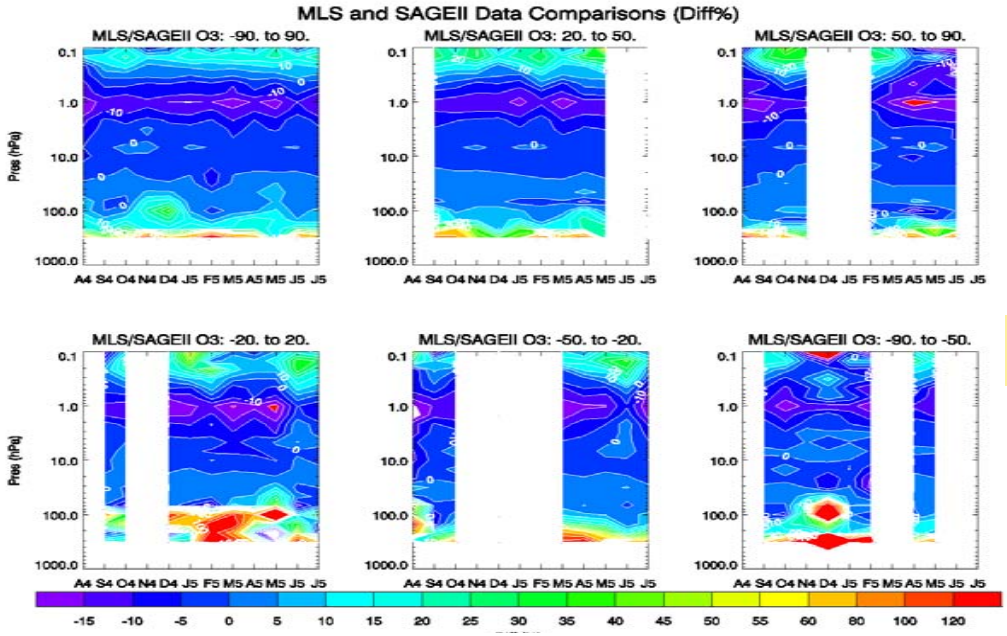
High MLS bias at P greater than or equal to 100 hPa.

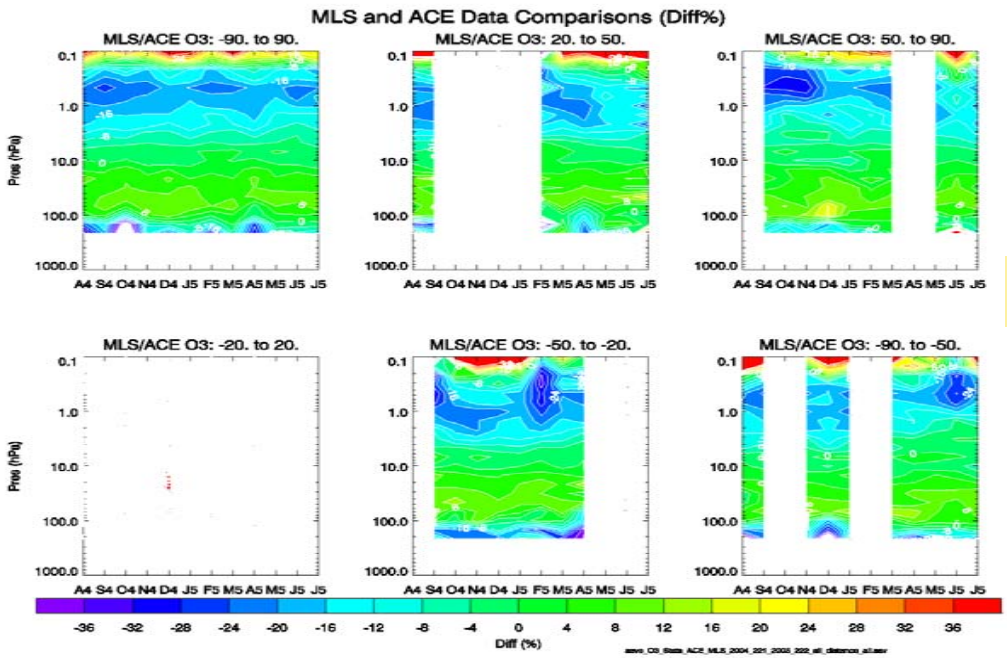


MLS vs ACE for ~ 1 year of data

Good stability vs latitude.

UT/LS bias goes opposite way vs ACE (so ACE gives even higher values vs SAGE II).





Time series of percent differences in monthly averages (coincident profiles)

Various Latitude bins.

MLS vs SAGE II for ~ 1 year of data

- Somewhat preliminary plots; need to check some of the spikes.
- Fairly stable otherwise.
- Plan to quantify this further (later on).

MLS vs ACE for ~ 1 year of data

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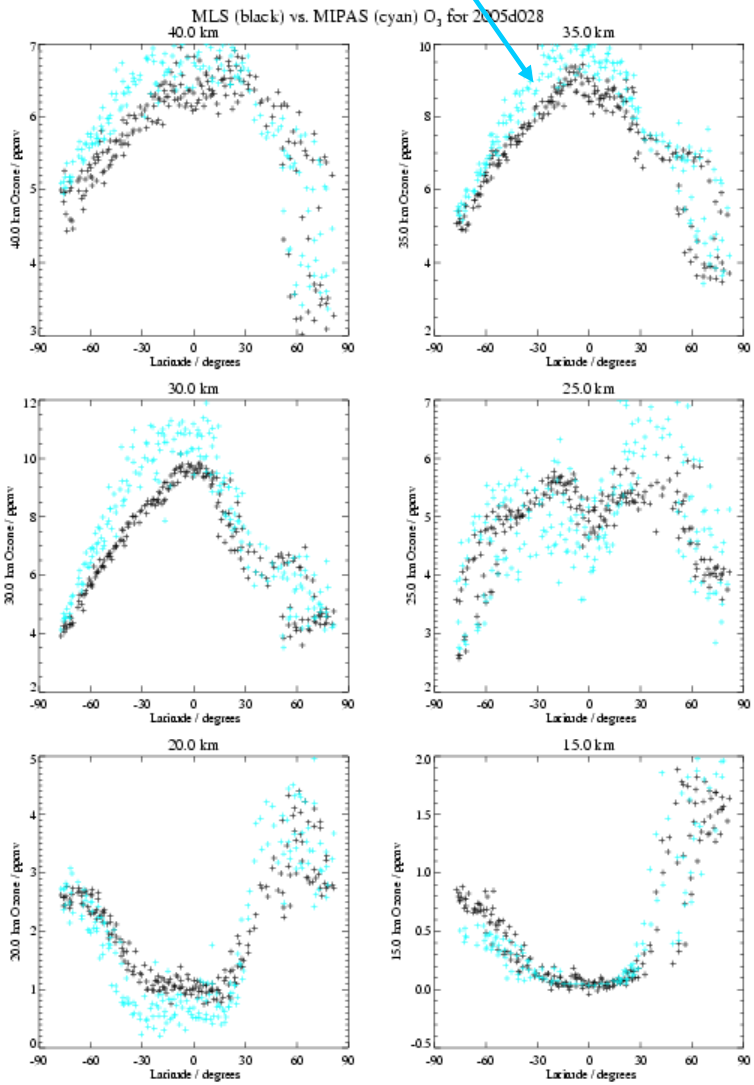
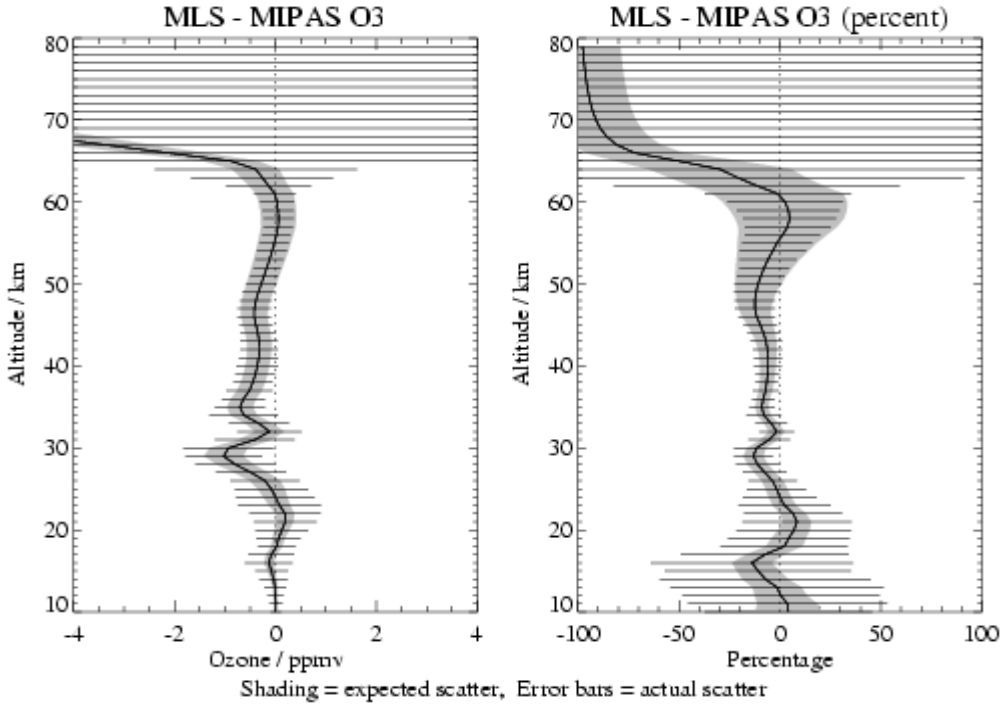
MLS O_3 vs MIPAS O_3

28 Jan. **MIPAS retrievals** (preliminary) from Claire Waymark, Oxford University; coincident MLS profiles shown below vs lat. at a few heights



Plot by N. Livesey



Average Differences & Percent Differences.

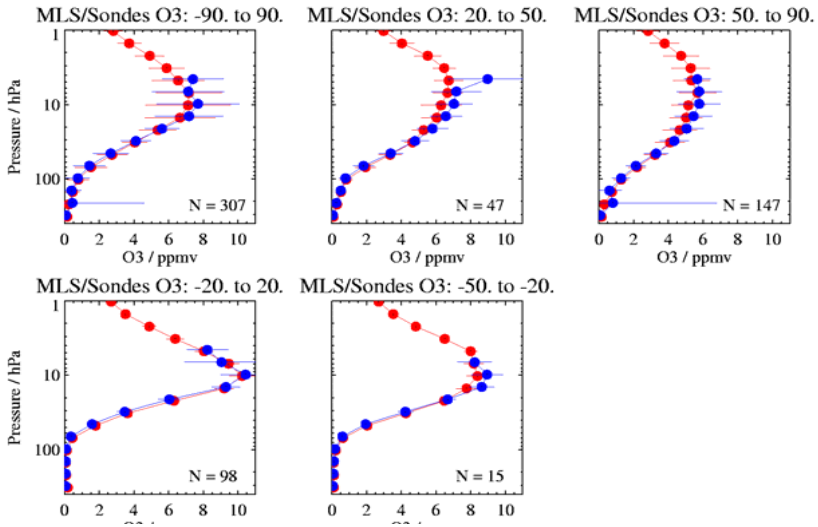
MLS values are most often lower than MIPAS by 5-10% and within ~ 10% up to ~ 60 km.

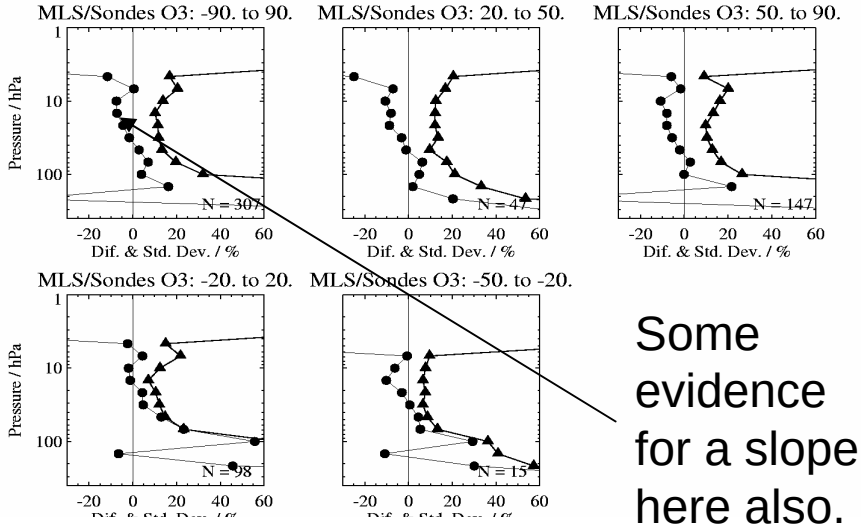
Would want more comparisons for firmer conclusions. Pattern of differences here is different than MLS vs occultation datasets.

MLS Ozone vs ozonesondes

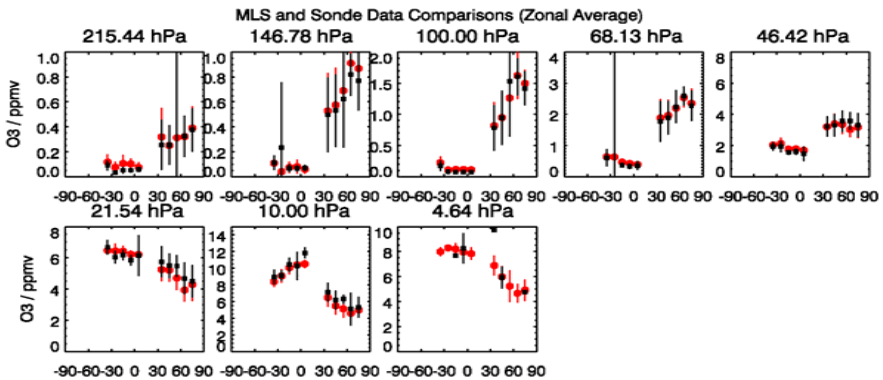
(mainly for stratospheric column purposes in these slides)

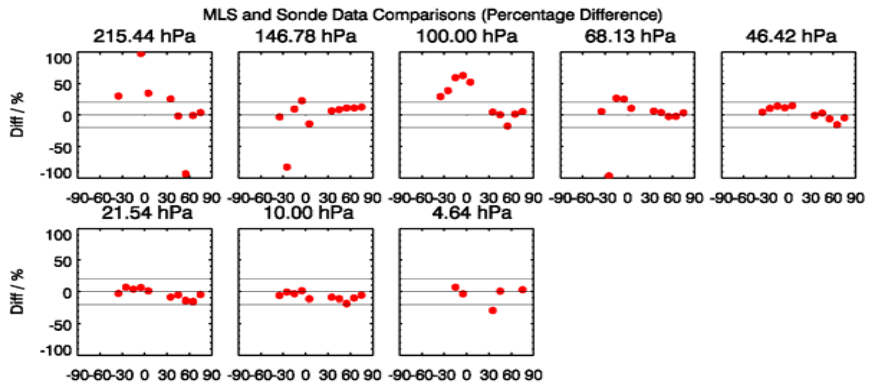
Special thanks to B. Bojkov for helping to obtain and convert many ozonesonde datasets in recent months + to all those involved in those many datasets.

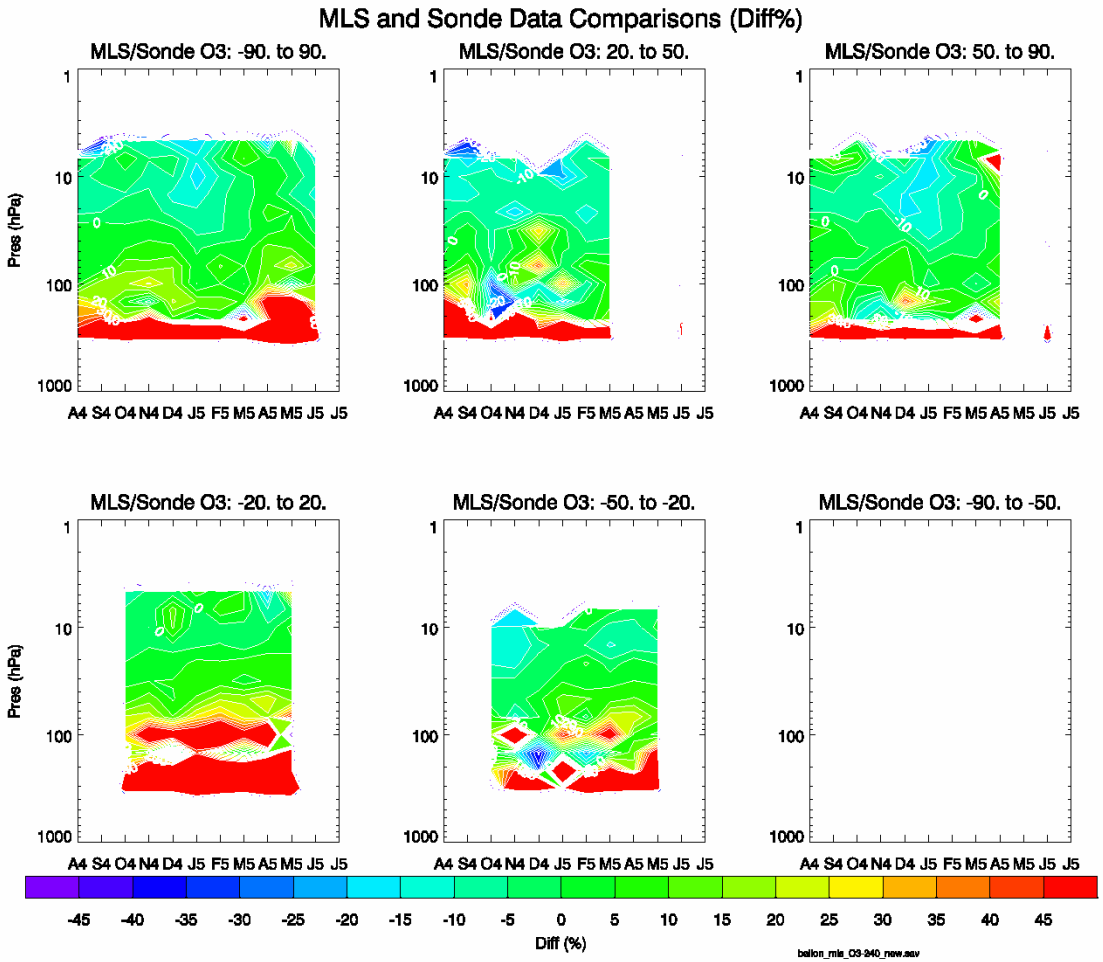




Some evidence for a slope here also.







Would like to add more sonde data to this.

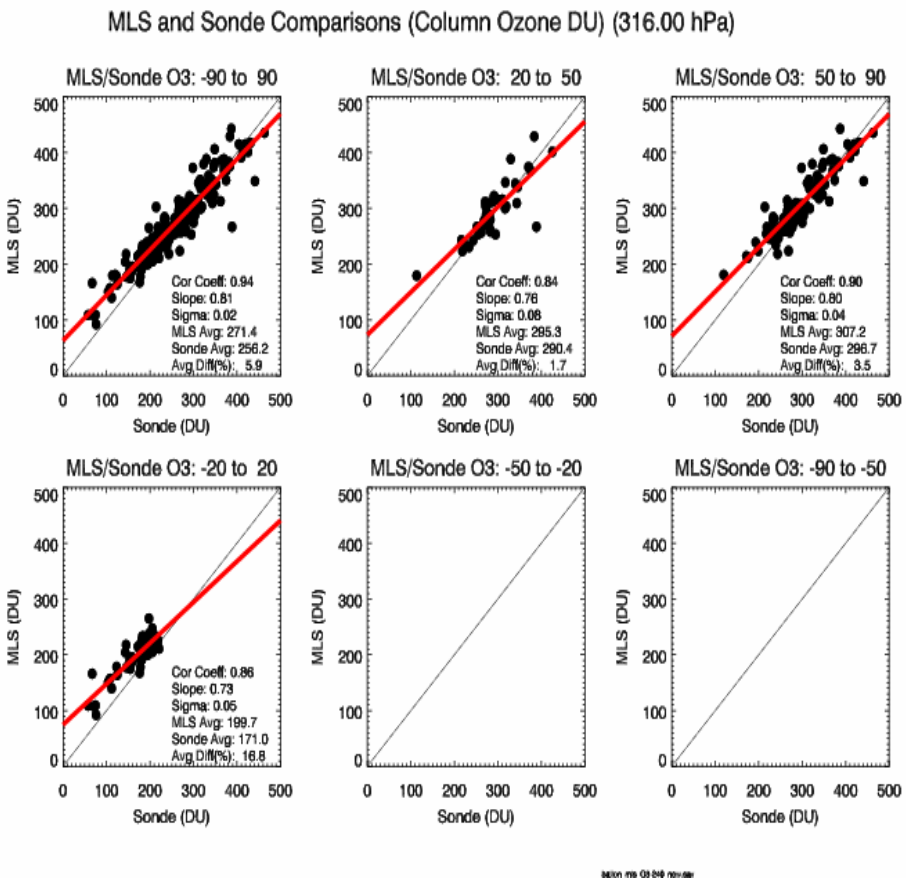
Also, ensure that no outliers exist in the sonde datasets, as this could lead to some artifacts.

More detailed comparisons versus sonde data in UT region shown by M. Filipiak (in trop. O3 session) → High bias (scaling error) seen in MLS data.

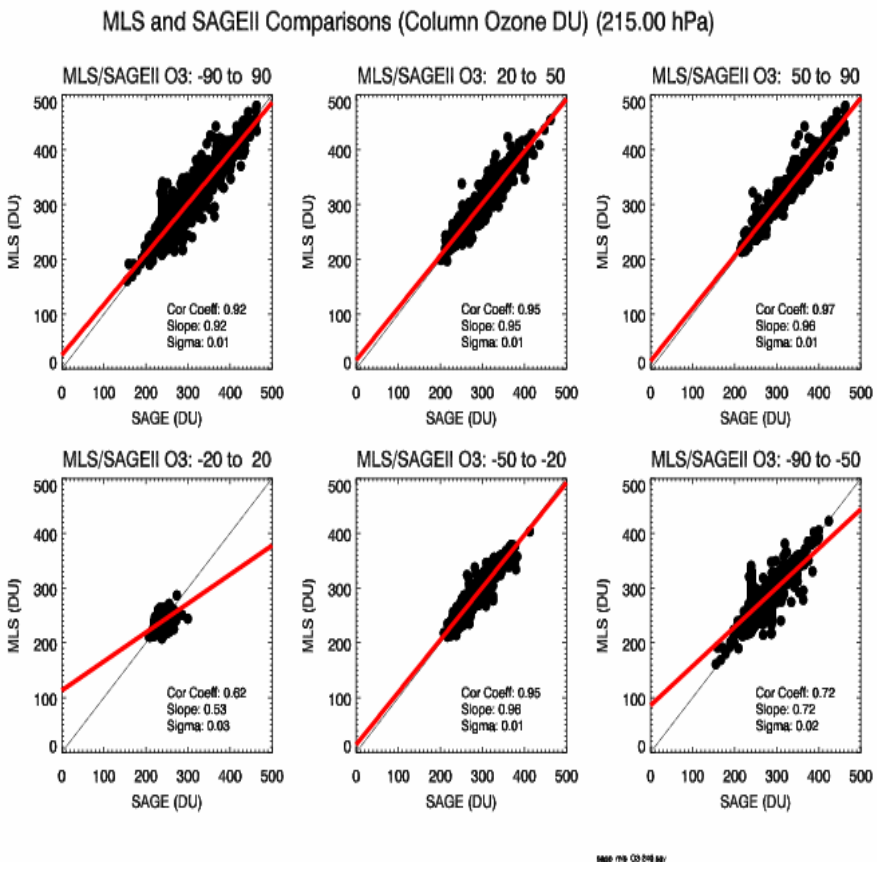
Preliminary Column Ozone Comparisons

Column ozone above 215 hPa (results also exist for other pressures)

MLS vs sondes



MLS vs SAGE II



MLS column abundances above 215 hPa tend to show a small positive bias (1-2%) vs sonde data, but are very close to the SAGE II columns (within 1%).

- Largest diffs. are in the tropics and for small column values.
- Consistent with a positive bias in the profiles at low altitude (will look at this more)

MLS O_3 versus O_3 from PAVE Lidars (AROTAL, DIAL)

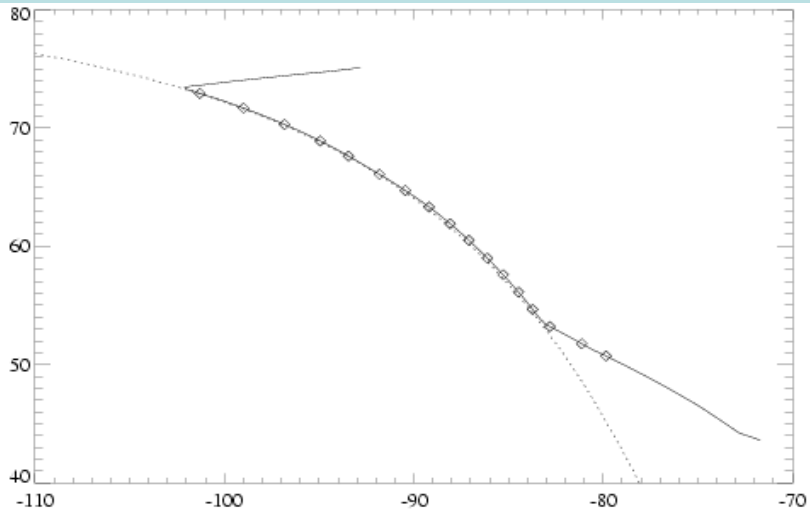
Approach

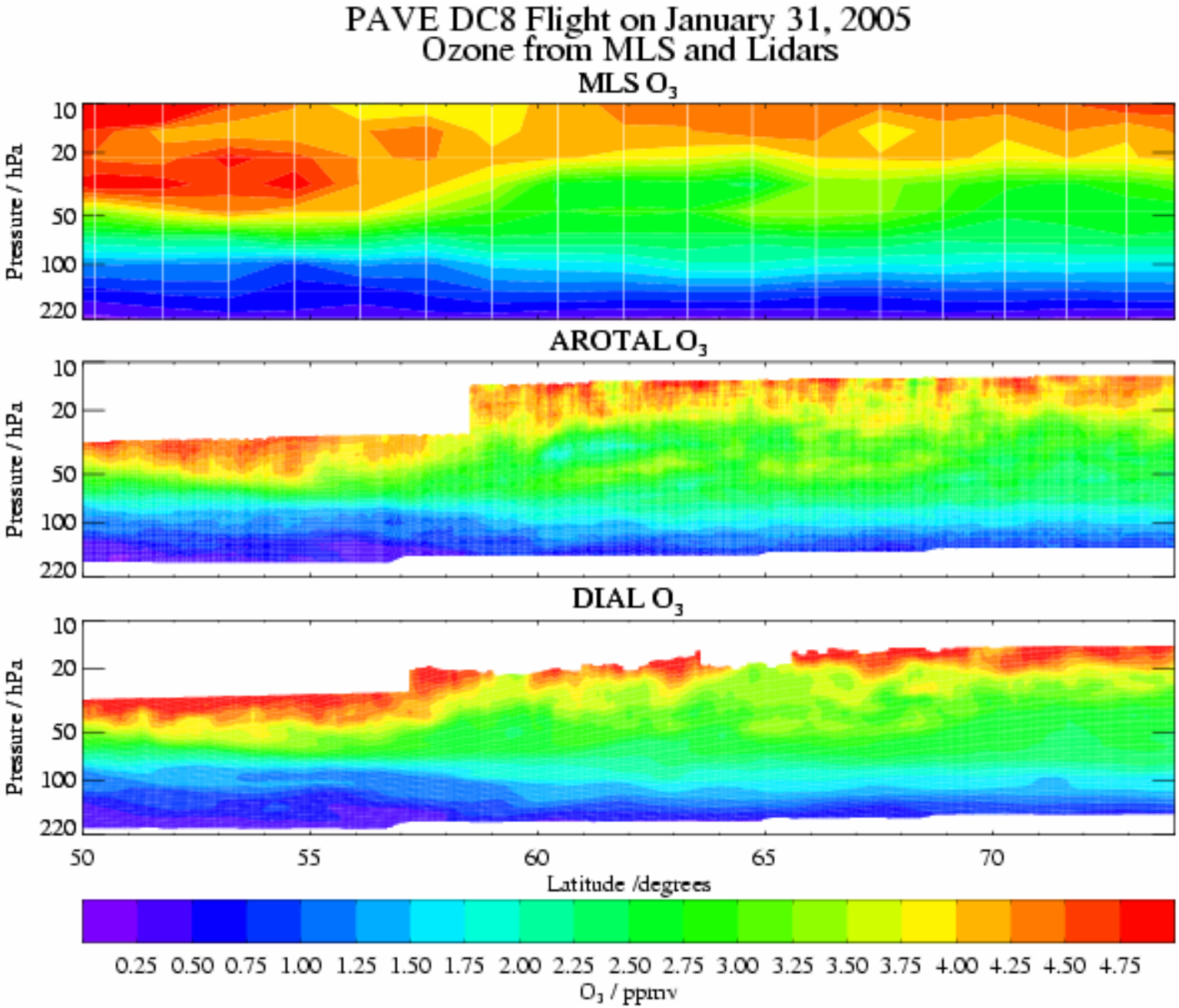
- Curtain plots for 3 days of aircraft flights in 50N to 70N region on Jan. 27, 31 & Feb. 5, 2005.

→ 4 curtain plots (one day has 2 legs).

- Downgrade resolution of lidars to 'look like MLS resolution'.

- Provide difference curtain plots and summary statistics for all the differences.

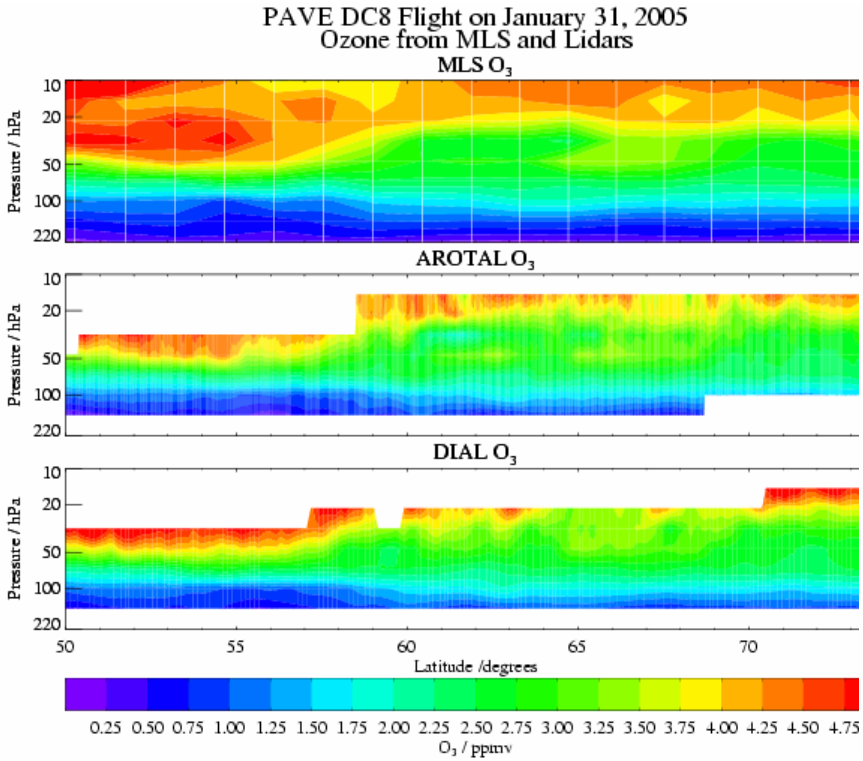




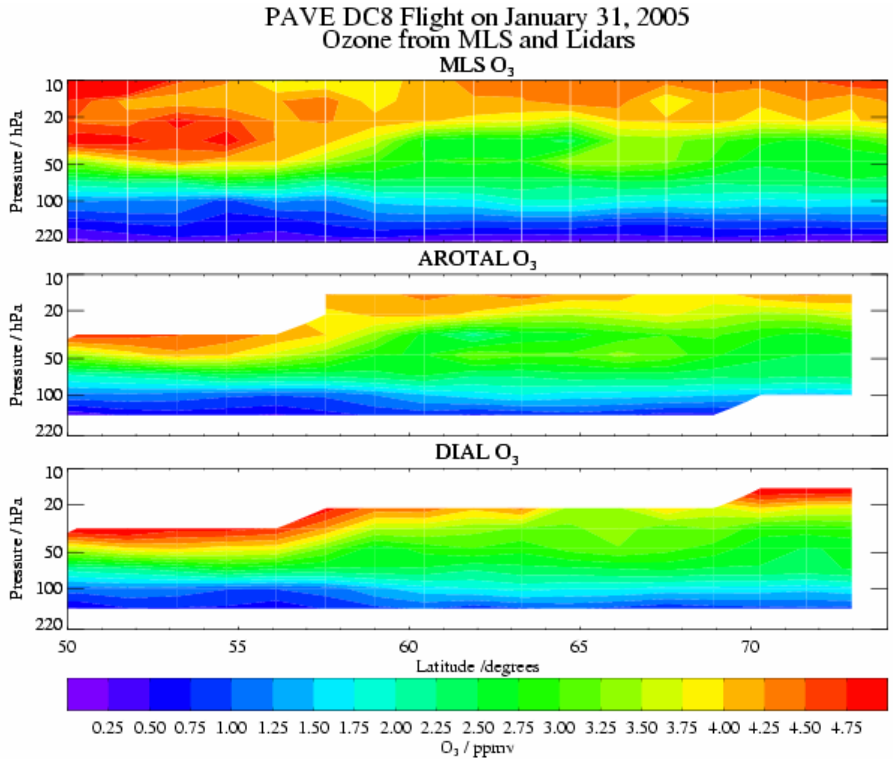
Lidar data shown here uses 'full' resolution from the data files.

MLS O_3 versus O_3 from PAVE Lidars (AROTAL, DIAL)

Smooth lidar data vertically …

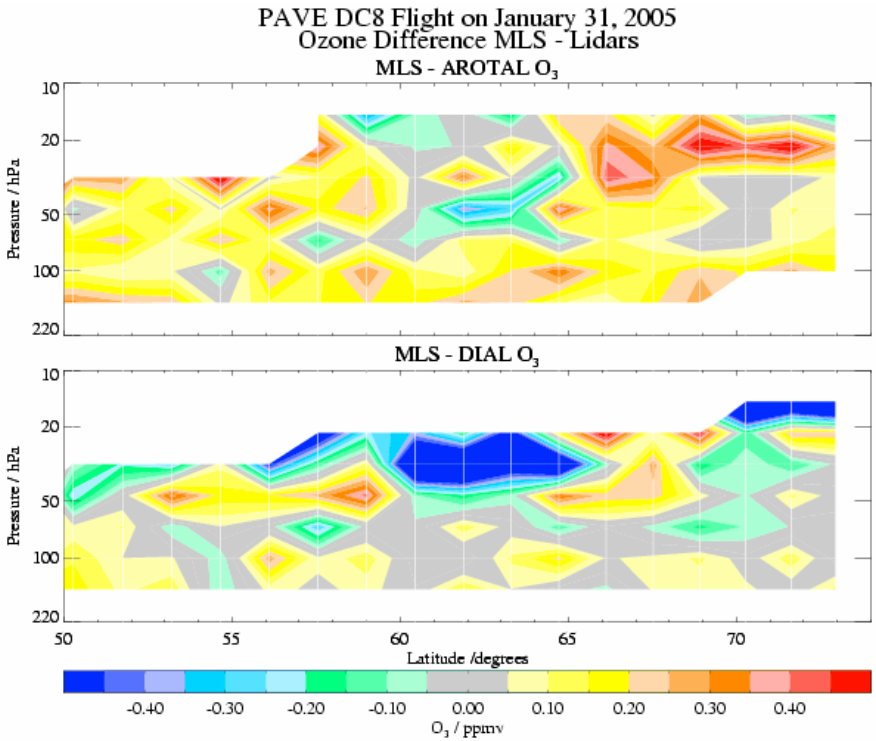


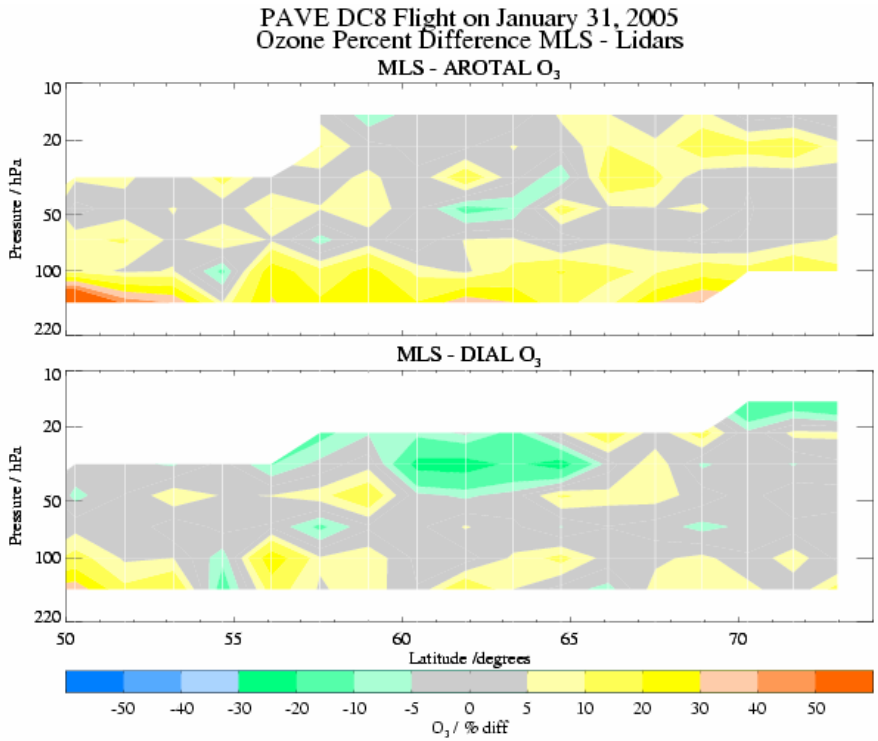
and horizontally



Very similar vertical and horizontal atmospheric variations are observed in the three datasets.

MLS O_3 versus O_3 from PAVE Lidars (AROTAL, DIAL)

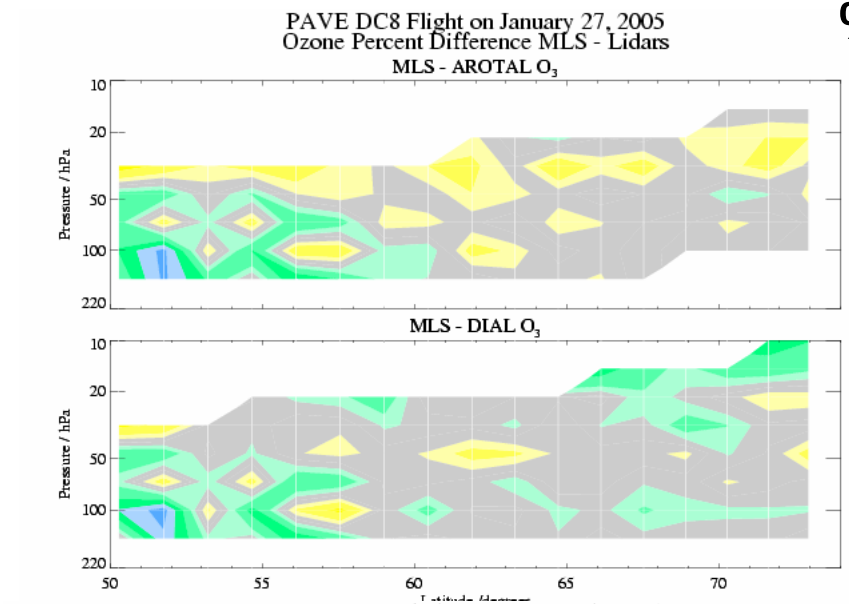


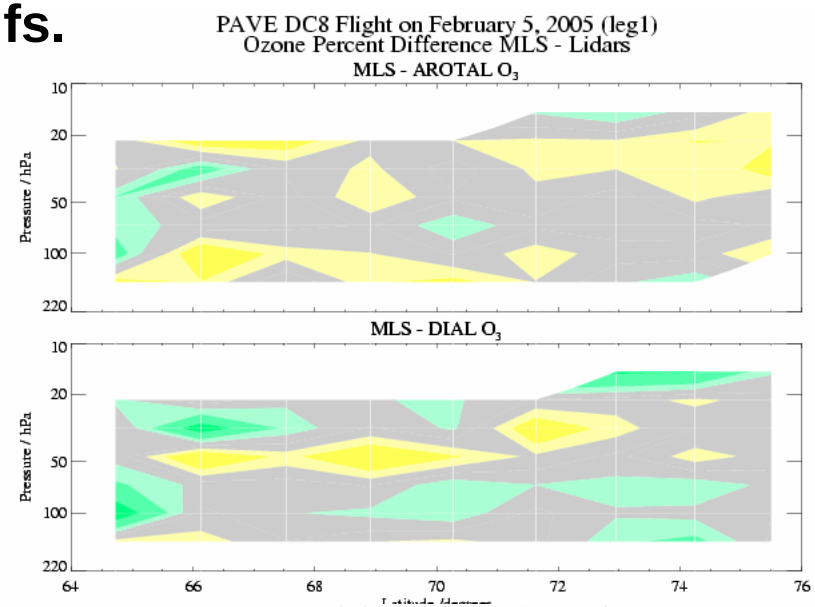


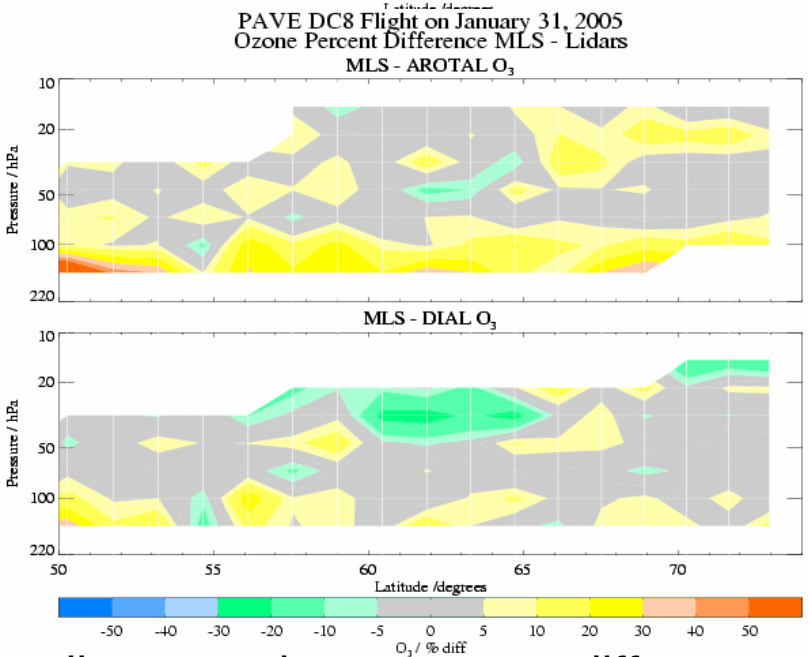
Differences and Percent Differences

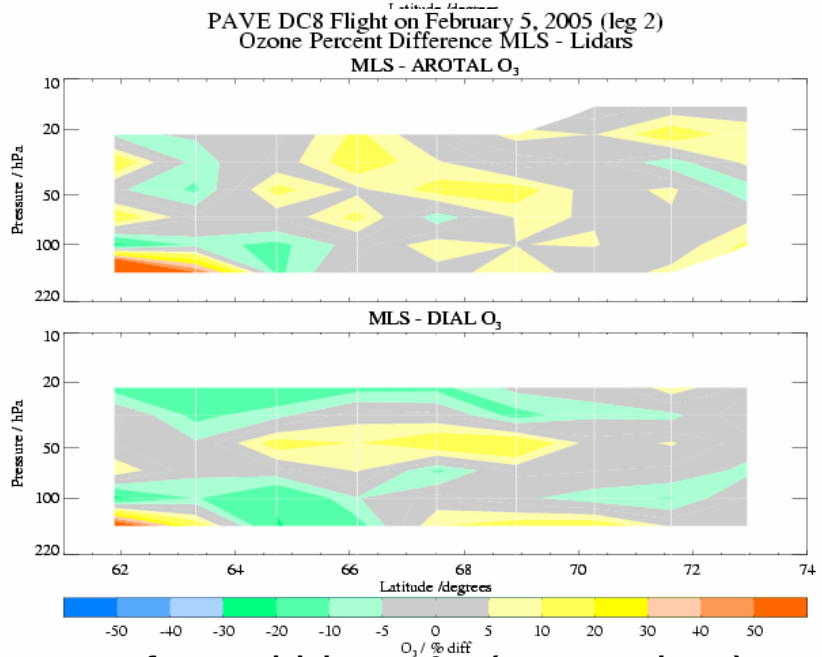
(MLS – Lidar)

% Difs.





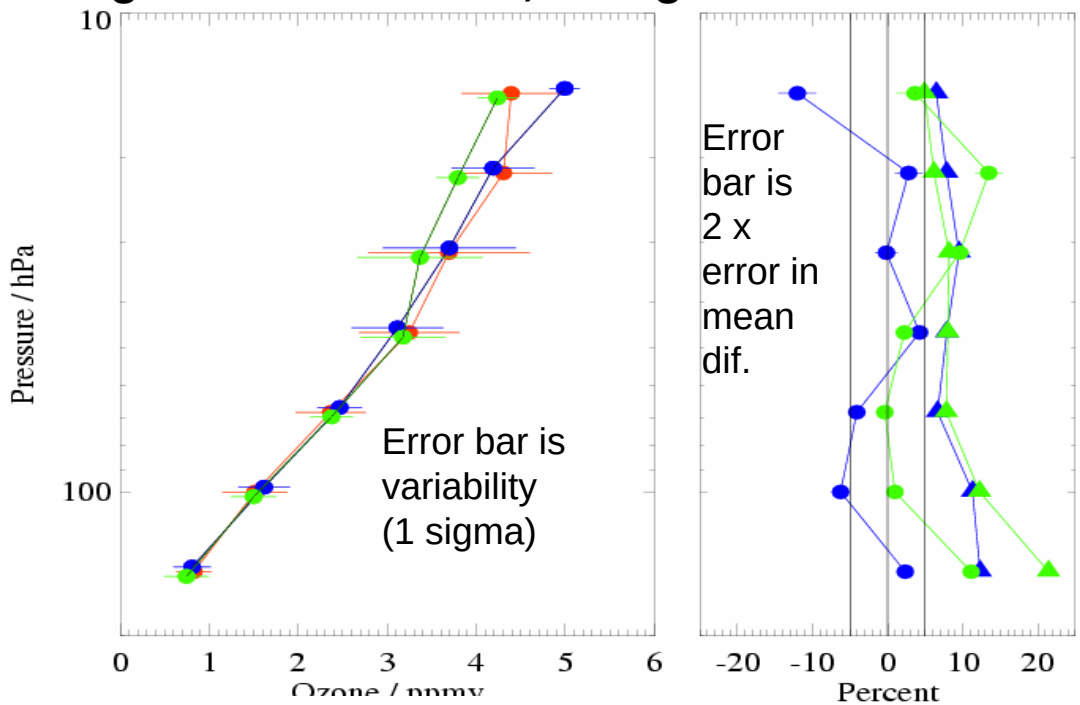


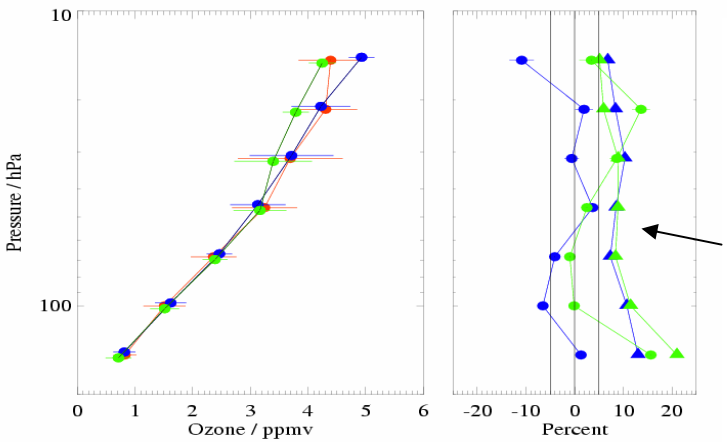


For all 4 cases here, percent differences are most often within ~5% (grey colors).
Some difs. are as high as 20%, but need to look at errors & statistics (see next page).

PAVE O_3 : Preliminary summary of results from MLS & lidar comparisons

Left: MLS: red; AROTAL: green; DIAL: blue
Right: Dot:mean dif.; triangle: std. dev. of difs.

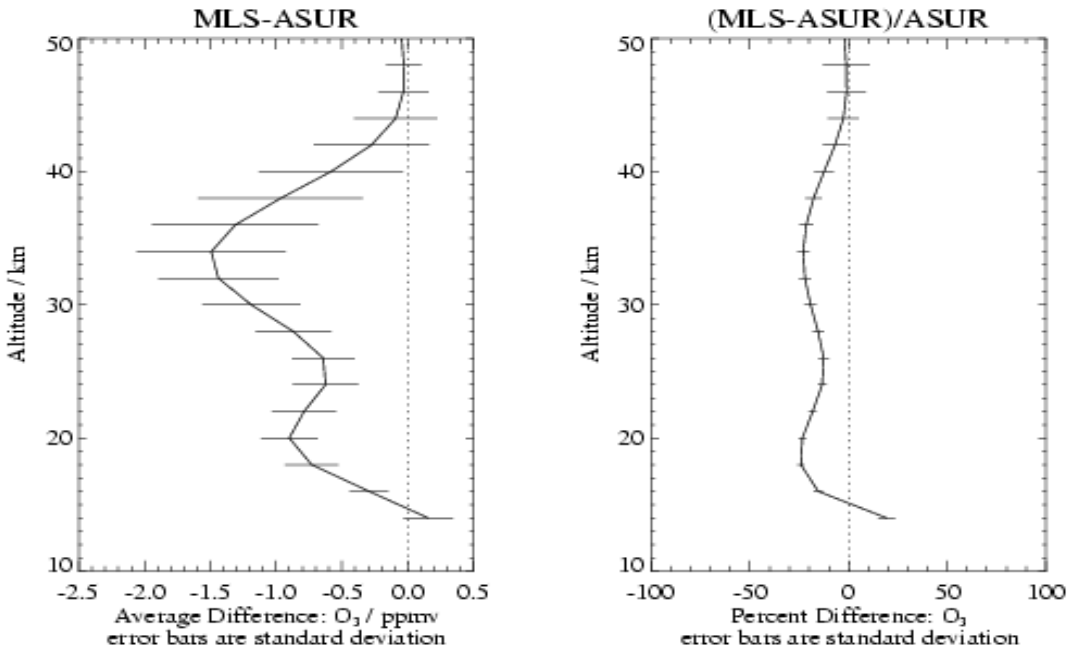




Simple vertical interpolation of lidar profiles gives very comparable results

- MLS O_3 abundance is within ~ 5% of the lidar, if use a vertical & horizontal smoothing of lidar profiles to match the MLS view of the atmosphere.
  - 61 avg. profiles considered here (Jan. 27, 31, Feb. 5).
- Not clear that one should expect much better than this (prelim. MLS accuracy estimate is roughly 5%, mid-upper strat.).
- Differences between the lidar profiles also seem to be at the few percent level, when looked at this way (but possibly not significant).
- Results shown here appear to agree with other studies discussed earlier this week (PAVE meeting).

MLS vs PAVE (ASUR)



[from ASUR comparisons
by M. Santee & N. Livesey]

Average of 65 MLS 'close' coincidences (from underpasses of Aura during PAVE) are shown here.

Individual profiles available (not shown here…).

The 10-20% low bias for MLS vs ASUR is not seen in MLS vs lidars (agreement is close to 5%).

If MLS/ASUR and MLS/lidar results hold,
ASUR O_3 should have a high bias vs the lidars ...
(H. Bremer says that this is indeed the case)

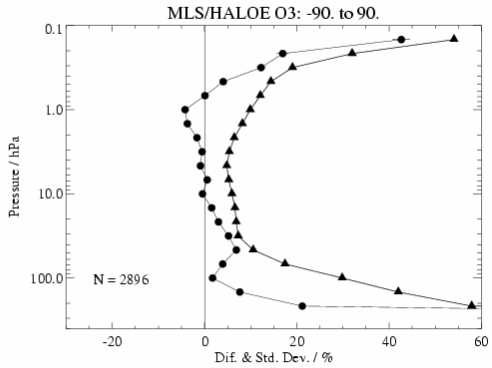
MLS O_3: Summary and Future Work

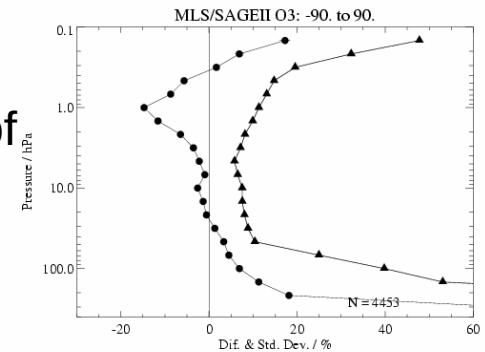
- Stratospheric ozone from MLS looks like a high quality product, most often within ~5-10% of other robust datasets.
  - Note: differences between SAGE II and HALOE can be of order 5% or even 10% *(see e.g., Nazaryan et al., JGR, 2005).*

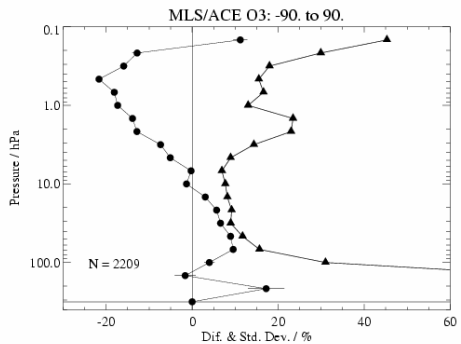
- Caveats:
  - A small slope in the differences vs height exists, but varies between datasets used for comparison (smaller for HALOE and POAM III, larger for ACE).
  - Lower limit of recommended range is 215 hPa, and less viable in the tropics (high bias) [see tropopshere session].
  - Upper limit is 0.46 hPa, for now, conservatively, because of higher % bias above this; useful info. exists intp upper mes.

- Mesosphere: MLS < SAGE II near 1 hPa (50 km);
  - however, SAGE II generally < HALOE there by 5-10%, so this seems to be consistent with MLS comparisons vs HALOE & SAGE II in that region (as MLS is closer to HALOE there).

- Column values down to 215 hPa seem to be within 1or 2% of SAGE II column values; close to (partial) columns from sondes also, but MLS shows high bias in tropics.
  [how does this relate to SAGE II comparisons? TBD]
  - Maybe CAFS columns should be closer to MLS columns…
  (to be continued).







MLS O_3: Summary and Future Work

- Investigate causes of sloping differences vs height (sensitivity of retrievals to errors in spectroscopy, pointing, etc…).

- Higher priority: high scatter & positive biases in UT/LS
  [see M. Filipiak's presentation in troposphere session]

- Lower priority: positive biases in mesosphere; other MLS bands give lower values there, so may be issue with narrow DAC channels at 240 GHz.
  - Issues of diurnal corrections in solar occultation datasets could also play a role (not applied in same way for each one of these).
  - Get more clues from comparisons vs ground-based datasets (lidar, microwave) into the mesosphere; also possibly from Odin/SMR, MIPAS (emission data).

- Continue / refine comparisons of the kind shown here.

- Incorporate improvements into future MLS software version; priorities for next MLS version are still being discussed.